Absorbing materials used in optical modules



Overview

The optical principles and methods used to evaluate the performance of solar absorber devices with broad applications in different physical conditions are presented.

Key Takeaways

Optical modules use specialized absorbing materials to capture light efficiently, including thin-film semiconductors, lossy films, and impurity-controlled substrates, tailored for specific spectral ranges and device applications.

Types of Absorbing Materials

Semiconductors and thin-film absorbers are widely used in optical modules, particularly in photovoltaic and photochemical cells. Materials such as silicon, copper indium gallium selenide (CIGS), cadmium telluride (CdTe), and emerging complex phosphides, chalcogenides, oxides, and nitrides are engineered to absorb light efficiently across targeted wavelengths, often with tailored bandgaps for multijunction devices or photoelectrochemical applications. Ultra-thin lossy films exploit interference effects to enhance absorption in films much thinner than the incident wavelength.

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These absorbers rely on loss-induced phase shifts and critical coupling, enabling compact designs without nanoscale patterning, suitable for decorative photovoltaics, infrared scene generation, and high-efficiency photochemical cells. Optical substrates with controlled impurities can also serve as absorbers. For example, fused silica absorbs light at specific wavelengths due to hydroxide (OH-) ion impurities, while IR-grade fused silica reduces OH- content to improve near-infrared transmission.

Absorption can occur via electronic transitions or as thermal energy, and careful material selection minimizes unwanted fluorescence and heat-induced degradation.

Design and Simulation Tools

Simulation tools like the Setfos absorption module use transfer matrix formalism to model photon flux through multilayer stacks, allowing optimization of layer thicknesses, spectral absorption, and angular or polarization dependence. This is particularly useful for thin-film photovoltaic devices, including perovskite, CdTe, and CIGS solar cells, where maximizing absorption in the active layer is critical for efficiency.

Applications

Absorbing materials in optical modules are applied in: Photovoltaic devices for efficient light-to-electricity conversionPhotodetectors and sensors for selective wavelength detectionLaser optics to manage unwanted reflections or fluorescenceInfrared and thermal imaging using interference-based thin filmsPhotoelectrochemical cells for hydrogen generation or CO_2 reduction Key ConsiderationsWhen selecting absorbing materials for optical modules, factors include: Spectral range: Matching the material's absorption band to the target wavelengthLayer thickness and interference effects: Optimizing thin-film absorbers for maximum light captureMaterial purity: Minimizing impurities to reduce unwanted fluorescence or thermal hotspotsIntegration with device architecture: Ensuring compatibility with multilayer stacks and electrical performance By combining material science, thin-film engineering, and simulation tools, optical modules can achieve high absorption efficiency while maintaining compact and practical designs.

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Article Content

Solar-Absorbing Materials | Materials Science | NLR

NLR''s materials discovery and design researchers work to discover new light-absorbing semiconductors and develop existing absorbers to enable technologies such as thin-film photovoltaic

Optical Properties of Solar Absorber Materials and Structures

The optical principles and methods used to evaluate the performance of solar absorber devices with broad applications in different physical conditions are presented.

Characterization of UV–Vis–NIR optical constants of encapsulant for ...

Characterisation of the optical constants of these materials is important for simulation (analytical model or ray-tracing), numerical prototyping and loss analysis of various PV module

On current technology for light absorber materials used in highly ...

The performance of these solar cells relies considerably on the light-absorbing material that generates electron–hole pairs through optical absorption and separates the generated charge

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A conformal optical transparent metamaterial absorber with broadband absorption extending from 5.3 to 15 GHz is developed, constructed, and measured to prove the method''s

Optical absorbers based on strong interference in ultra-thin films

In this article, we summarize recent progress in the development of optical absorbers based on lossy films with thicknesses significantly smaller than the incident optical wavelength. These structures

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This study pioneers the application of computer numerical control (CNC) drilling technology for fabricating high-absorption material templates, enabling precise control over

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This book provides the optical principles and experimental methods required to realize high performance of solar selective absorbers.

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Unlocking the secrets of efficient solar cell materials

A multi-institute team led by Oxford has unravelled the factors enabling efficient charge-carrier transport in the light-harvesting materials for solar cells, in a work published in Nature

Materials for optics

Overcoming the trade-off between colouration and high solar reflectance is a challenge for radiative cooling materials. Now, an ethyl cellulose coating fabricated in one step achieves vibrant...

The Evolution of Optical Modules: Powering the Future

Enter optical modules, which leverage the power of light to transmit data efficiently over long distances, driving the next generation of technological

Common Laser Optics Materials

Understanding the most commonly used laser optics materials will allow for easy navigation of Edmund Optics'' wide selection of laser optics components. Table 1

Multifunctions of microwave-absorbing materials and their potential ...

Abstract Microwave communication technology is widely used in numerous applications, from telecommunications to medical devices. However, the excessive use of microwave devices has led

Ultra-wideband optically transparent flexible metamaterial absorber for ...

However, traditional absorbing materials do not adequately address the requirements for flexible conformal designs, high transmittance in the visible light spectrum, and ultra-wideband

Intraocular Lenses: Overview of Designs, Materials, and ...

This article provides an overview of intraocular lenses (IOLs) currently used in cataract surgery. Aspects presented include design features related to IOL construction and sites of fixation;

Basic Science of Intraocular Lens Materials

This chapter will explain the materials used in making intraocular lenses. Rigid IOL''s made of PMMA have now given way to foldable silicone and acrylic lenses. This chapter will also

Anti-laser enables near-perfect light absorption

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The researchers also used a number of techniques to create rapidly changing, complex and random light fields. Even with these dynamic variations in the light source their coherent perfect

CURRENT TRENDS IN THE RADAR ABSORBING MATERIALS

Abstract. The study of materials with properties of reducing or blocking electromagnetic radiation used in RADAR detection has gained momentum in recent years, especially after the discovery of graphene

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